Final Report

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

ENERGY EFFICIENT HOME

28

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Bathurst, N.B.

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C.R.E.D.A. PROJECT #104

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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D E N I D E R E S P O N S A B I L I T E

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1.0 Executive Summary

The objective of this project was to provide a reasonably priced energy efficient home using technology which was readily available, hopefully field proven or at least tested, and suitable for installation by local contractors.

Specifically the dominant feature of the project is a continuous, sealed vapour barrier greatly reducing heat loss by air exchange. This is supplemented by high levels of standard insulation and the orientation of 84% of the glazed area to the south.

The vapour barrier was highly successful when air quality is not considered. Similarly the passive solar feature was also successful. Finally the high R values of the fibreglass and cellulose insulation can be maintained for many more years because water vapour is unable to pass from the house into these areas.

1.0 Résumé

Ce projet avait pour but de construire une maison à haute efficacité énergétique à un prix raisonnable en utilisant une technologie facilement disponible et en espérant qu'elle ait été prouvée sur le terrain ou du moins testée et adéquate pour installation par les entrepreneurs locaux.

La particularité dominante de cette maison est un pare-vapeur continu et scellé qui réduit les pertes de chaleur par les échanges d'air. Ceci s'ajoute à un niveau d'isolation élevé ainsi qu'au 84 % de la surface vitrée qui est orientée vers le sud.

Sans tenir compte de la qualité de l'air, le pare-vapeur a fonctionné avec succès. Il en a été de même pour les modifications reliées à l'énergie solaire passive. La valeur R élevée du fibre de verre et de l'isolation de cellulose peut être maintenue pour plusieurs années puisque la vapeur d'eau ne peut s'y infiltrer.

2.0 Introduction and Background

Arriving in Canada from a milder climatic area and from an already established energy crisis in Europe I was amazed at the profligate use of energy and the little thought given to the design and construction of energy efficient housing. My concerns increased after receiving electricity bills of over $100 per month in 1977 for a two bedroom apartment - this with the thermostat set at 18°c (65°F) for much of the time.

A building lot was purchased in 1978 which had a north-south orientation, the road being on the north side, and sufficient depth to the lot (64 m, 210 ft) to maximise the benefits of passive solar energy.

Together with high levels of insulation and, most importantly, a continuous sealed vapour barrier it was hoped to build one of the tightest houses in the Maritime area. This house was to be built at little extra cost (approximately $6000) and the initial costs would be paid back within six years by the energy savings.

Active solar technology and thermal mass were briefly considered but rejected because of unproven technology or inappropriateness for this locale. After considerable research it was decided to go with a simple construction technique that should present no problems to builders in the area. Air tightness was a continuing theme in much of the literature, particularly from Saskatchewan where it was well proven, and passive solar gain seemed both aesthetically pleasing and environmentally acceptable.

It was hoped to heat the home for a maximum of $2.00 per day in the depth of winter. This would project into savings of between $600 and $1000 per annum with a pay back period of 9 to 13 years. In terms of energy conservation this interprets as a saving of between twenty and thirty thousand kW hours per heating season.

A market for this type of construction is readily identified. No one wishes to pay heating bills of $120 to $200 per month. Tight, well insulated houses are quiet, remain warm in winter with no drafts and keep cool in summer. Such houses also have an excellent resale potential.

3.0 General Description of the Demonstration

Air tightness was achieved by installing a continuous sealed vapour barrier of 6 mil plastic. This vapour barrier was taken around the floor joists and across the ceiling of the upper storey. Where joins were necessary the plastic was well lapped, sealed with caulking and strapped with 2" X 2" strapping, in effect creating a large air tight plastic bag.

High levels of fibreglas or cellulose insulation were used and the house was sheathed externally from footing to eaves with 3.8cm (1.5") Styrofoam. The house was constructed so that 84% of the glazed area faced south to maximise solar gain. Finally to help keep this heat inside, air-lock, weather stripped entrances were constructed for both front and rear and insulated movable shutters were installed on three of the largest windows.

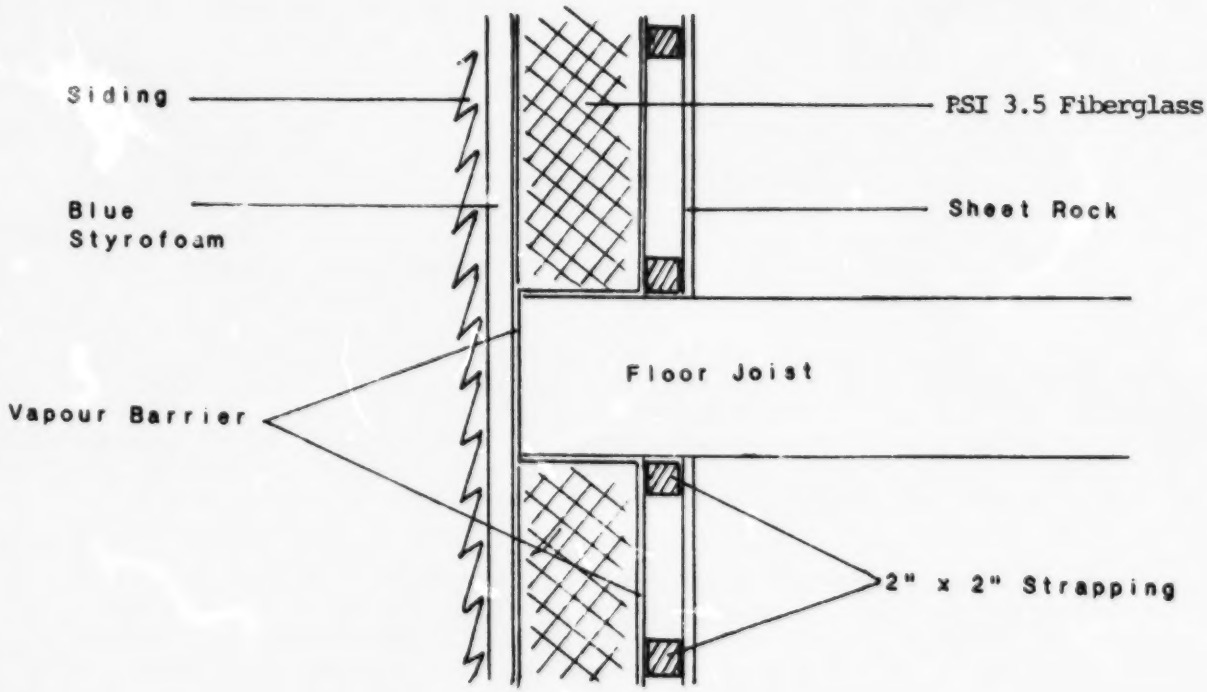

Figure 1. CROSS SECTION OF WALL

4.0 Observations During Installation and Monitoring

As several energy conserving features are incorporated in the house each will be considered separately.

(a) Continuous Vapour Barrier

This item was to be installed by the contractor under the strict directive of 'no perforations of any size'. It became obvious after the installation of approximately 12 running metres (40 ft) of this barrier that the contractor and his employees had absolutely no concept of the purpose of a vapour barrier. The contractor cut the 6 mil plastic completely from floor to ceiling whenever a corner, doorway or window was reached. In addition, the plastic was attached to the studs using a hammer staple gun and up to 20 staples per stud, the effect of this being that each staple was surrounded by a small tear. The vapour barrier installed around the joists was allowed to drag on the floor and was torn repeatedly at the critical junction of the floor and wall.

It was decided that the vapour barrier around the joists was attached carefully to the studs to prevent people walking on it and to prevent the wind tearing it. For the wall vapour barrier, with only two people, it was possible to carefully unwind a 10 foot wide roll of 6 mil plastic in the upright position against the wall and by maintaining a tension on the roll attach it to every fourth or fifth upright, with a maximum of four hand driven staples. Plastic over the windows and doors was cut to permit caulking and careful stapling to the outer edges of the window or door thus completely sealing the difficult gaps around these installations.

The ceiling area was covered using one roll of twenty foot wide 6 mil plastic. With five people unrolling it the plastic was strapped with 1" X 3" strapping to the ceiling joists.

Installation of the vapour barrier should, for the present, be undertaken by the project owner and after installation must be carefully inspected for subsequent perforations particularly at the sheet rock stage. By following these guidelines a highly efficient vapour barrier was installed.

(b) **Fiberglass Insulation**

This was initially compressed into the wall cavities, was installed before the siding was fitted and was abused by compression or other uses i.e. for maintaining heat in the basement when the concrete floor was poured. The fibreglas batts were later removed and installed by the owner after the siding was installed.

(c) **Insulated Shutters**

These were joined by wooden dowels on site and were installed with some difficulty. Warping of the shutters occurred and the sliding door track used created problems when the shutters came off the track.
These problems were not solved and in addition the shutters created considerable condensation problems on the windows and sills when the shutters were closed at night.

(d) **The Furnace**

The engineers oversized the furnace by 100% assuming that the energy conserving features would not be installed correctly. Fortunately the vapour barrier and insulation were installed correctly and consequently the house becomes too hot when the furnace is alight. In addition the furnace was installed disregarding local fire regulations.

(e) **Wing Walls**

The purpose of these was not understood by the contractor and one wing wall shown on the plans was not built. The wing wall at the rear east corner of the house has been effective from an energy conservation view point and also adds privacy to the house.

(f) Windows

Double glazed, Pella windows, were installed but unsuitable for this climate as condensation occurs between the panes, the vent holes became blocked by wasp larvae and the mere presence of vent holes negates the double glazing. In retrospect triple glazing, which includes one thermopane unit, would be the logical choice.

5.0 Cost/Benefit Analysis

5.1 Cost Accounting

The total project cost was $7205 of which $4662 was funded under the Conservation and Renewable Demonstration Agreement by the N.B. Energy Secretariat and Energy, Mines and Resources Canada. The remaining $2543 was paid by the owner. A detailed cost breakdown of the equipement purchased can be found in Appendix 3.

5.2 Payback Period

Hydro consumption is based on a print out from N.B. Power covering the previous twelve month period - print outs are not provided for periods before this. Based on this print out kWh used during the winter of 1983 to 1984 from November until April inclusive were 13,610 at a cost of $631. Hydro bills in August 1983 and June 1984 were $52.51 and $67.84 averaging close to $60.00 per month when the electric heat was turned off, totaling $360 over a 6 month period. Thus the true bill for the winter is $631 - $360 = $271. If one then removes costs for lighting and car plug in, estimated total $30, the winter bill is $241, or $40 per month or less than $1.50 per day. Compared to a conventionally designed house with the same dimensions which costs $1000 to heat, energy savings amount to $1000 - $241 = $759 per year.

This results in a payback period of $7205/$759 = 9.5 years.

6.0 Conclusions

Basically the objective to build an energy efficient home has been achieved but not without considerable problems encountered during construction. Certain additional features intended to enhance the energy efficiency were not successful and merely added to the capital cost of the project. Air tightness was definitely achieved as verified quantitatively by the air infiltration test performed indepdently by Jenkins Insulation of Bathurst (see attached Appendix 1). Similarly the superior insulation levels were acheived at little extra cost.

Such construction should be easy to achieve in any area at little extra cost but with major reductions in the use of energy. These houses are quiet, free from draughts, warm in the winter, remain cool in the summer and can be architecturally pleasing to the eye.

7.0 Recommendations

As clearly demonstrated the two main features of this project are exceedingly beneficial and relatively cheap to install, should present little technical difficulty. These features are:

1) A continuous, sealed 6 mil vapour barrier.

2) High levels of insulation.

The acceptance by the construction industry and home owners of the R2000 design clearly illustrates the value of these items.

Correct positioning of the house in relation to the north-south axis is important and passive solar gain in this area is beneficial particularly if glazing is concentrated on the south facing aspect. Vestibule entrances, acting as air locks, are of great value particularly if the homeowner has young children. These vestibules are fully used as part of the home.

Positioning of wing walls reduces heat loss from glazed areas and also provides a certain privacy. Similarly siting of the front door so that it is not facing north reduces heat loss.

Sheathing the house externally with 3.8cm (1.5") blue stryofoam added little extra cost as it replaced plywood sheathing and also insulated the basement walls. Berming on the north and west sides gave added insulation and is attractive but must be carefully considered where drainage is not good.

From the experience gained during the project construction it is strongly recommended that the owner install the wall insulation, vapour barrier and strapping himself and also be responsible for sealing perforations of the vapour barrier with templates or flexible seals. He should also ensure that the siding is placed on before installing the insulation.

Certain energy saving features incorporated into the project were not successful. The moveable shutters were positioned too far from the interior glazed surface and were not tight fitting, therefore, allowing continuous air flow behind them. This led to severe condensation problems and the shutters are no longer used. It is recommended that shutters should be tight fitting and within 1.3 to 2.5 cm (1/2" to 1") of the glass surface.

Pella windows are not recommended, unless they are thermal type, because of the vent holes. Triple glazing with thermopane is a far more efficient choice.

Correct installation of the vapour barrier and insulation allows incorporation of a furnace with a heat output maximum at or near that of the estimated loss on the coldest day (e.g. at -30 C). The project owner should not be persuaded to take an oversized furnace.

In retrospect placement of rigid insulation uder the basement floor would have been an additional feature to be included but the cost at the time was prohibitive. It has, however, been well documented by others that significant heat loss does occur through basement floors.

Discussion of tight houses with continuous vapour barriers often brings both the fear of excessive moisture with its attendant problem of mildew, walls streaming with water and in addition the problem of "difficulty in breathing". Certainly air quality is a problem but moisture has never been of concern in this project. It is felt that an air-to-air heat exchanger is necessary. At least the ducting and inlets should be incorporated at the time of construction with later fitting of the heat exchanger when money is available.

Although walls are estimated to have RSI values of 5.6 (R32), this figure is certainly lower because of a certain degree of thermal bridging by the 2 X 6's (this bridging, however, is not complete because of the outer covering of 3.8cm (1.5") stryofoam . A double wall structure of 2 X 4's eliminates bridging and insulation is easier to install.

The energy efficient features shown to be a viable proposition are easily installed in any house design, in fact in any building design. Passive solar gain is not so easily incorporated but has both economic and aesthetic advantages. For anyone considering building a home or having one built for them they should incorporate a continuous vapour barrier and high insulation levels as the pay back period is relatively short and the resale value of the house will increase as energy costs increase.

APPENDIX 1: Electric Power Consumption Record

```
ACCT NO    375665 16   44 447 13          STATUS      ACTIVE              PAGE  01
NAME       MILLER/JOHN                    SERV START  81/02/23
SERV ADDR  975 TAMARACK DR                SERV CLASS  RES          04
           BATHURST NB                    CIS ACT
           E2A 4G1                        POLE #      NA
********************************* BILLING HISTORY 1*********************************
                BILL                                CASH                 OTHER
RT DATE    CURRENT      SURCHG     DUE-DAY   REPORT      AMT       DATE CD     AMT
04 0620      67.84        1.68        10     910614     103.60
04 0522      94.13        1.81        11     930426      99.25
04 0418     101.84        1.71        08
04 0321      99.25                    10     930319     134.31
04 0220     134.31                    12     930209     144.44
                                             930124      89.61
04 0120     142.87        1.57        09
04 1220      89.61                    09     931212      63.15
04 1121      63.15                    12     931110      57.46
                                             931020      60.96
04 1020      58.59        1.07        09
04 0921      60.96                    11     920907      52.51
04 0822      52.51                    12     920809      61.88
ENTER TRANSACTION CODE OR PAGING REQUEST - P1      MORE HISTORY ON NEXT PAGE
```

```
ACCT NO    375665 16   44 447 13          STATUS      ACTIVE              PAGE  01
NAME       MILLER/JOHN                    SERV START  81/02/23
SERV ADDR  975 TAMARACK DR                SERV CLASS  RES          04
           BATHURST NB                    CIS ACT
           E2A 4G1                        POLE #      NA
********************** METER CONSUMPTION & DEMAND HISTORY **********************
METER NUMBER- 274645  BILL MULT- 00001
E  READ  R  KWH     KWH    DEMAND ACTUAL E  READ  R  KWH     KWH    DEMAND ACTUAL
C  DATE  C  READ    USAGE   READ  DEMAND C  DATE  C  READ    USAGE   READ  DEMAND
A 840611 0 65834     1171
A 840514 0 64663     1817
A 840411 0 62846     2007
A 840313 0 60839     2089
A 840213 0 58750     3002
A 840112 0 55748     3225
A 831214 2 52523     1838
A 831110 0 50685     1149
A 831013 0 49536      979
A 830913 0 48558     1092
A 830810 0 47466      892
A 830713 0 46594     1116
A 830608 0 45478
ENTER TRANSACTION CODE OR PAGING REQUEST - P1              1 OF 1  METER(S)
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APPENDIX 2: INFORMATION TRANSFER

1) Radio interview with C.B.C. Moncton. From this came enquiries seeking information: for example on air-to-air heat exchangers.

2) Coverage in the local press.

3) Open house for approximately 20 people.

4) Have been consulted on several occasions by at least five people on the incorporation of energy efficient features. At present have just finished writing several pages on energy efficiency accompanied by relevant articles from e.g. New Shelter, Harrowsmith

Appendix 3 Cost Breakdown

Contributions to the Project:

1)	Canada/New Brunswick Governments	$6,600 (60% of this)
2)	Project Owner	$2,400

Cost Breakdown of the Energy Saving Features:

1)	Windows shutters and hardware	$ 900
2)	Blue styrofoam	$1,200
3)	Weather stripping for vestibule doors	$ 40
4)	RSI-3.5 (R20) batts (fibreglas)	$ 300
5)	12" blown cellulose for attic	$ 540
6)	6 mil vapour barrier	$ 125
7)	Interior brick wall	$1,600
8)	Venting of ducts to basement	$ 125
9)	Air intake for furnace	$ 50
10)	2" X 2" and 1" X 3" strapping	$ 300
11)	Box beam	$ 325
12)	Berming of foundation wall	$ 300
13)	Wing Wall	$ 250
14)	RSI-2.5 (R14) interior doors	$ 100
15)	Metal covering for above grade styrofoam	$ 300
16)	Corner brace for framing	$ 250
17)	Vestibule exterior doors	$ 500
		$7,205